

# **Predictive Intelligence Military Tactical Analysis System (PIMTAS)**

## **Final Technical Report**

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# 1. Statement of Problem

The ancient Greeks used knowledge of the mountainous terrain at Marathon to defeat the Persians. General McArthur used knowledge of the tides to enable his troops to land at Inchon, Korea. Thus, from Marathon to Inchon, understanding of the local terrain has been critical to winning the battle. It is no longer possible to extensively study only a few areas, such as the Fulda Gap in Germany and the demilitarized zone between North and South Korea. Recent history has demonstrated that the terrain of interest may suddenly become Grenada, Panama, or the Middle East. Thus an automated terrain reasoning system would provide considerable assistance to modern battlefield commanders by enabling them to quickly and accurately analyze the terrain in areas that have suddenly become new combat arenas.

Currently there is no capability of automated route finding available for operational use in the Army. Manual terrain analysis performed in support of battlefield planning is tedious and time-consuming. A detailed terrain analysis of a strategically important area may take as long as a month to perform. Since it is not feasible to analyze in advance all potentially important areas, automated route finding would greatly facilitate modern battlefield operations. Military doctrine often calls for offensive forces to advance in three separate columns. The computer should therefore compute three optimum non-competing paths as well as sub-optimum alternatives. The three routes must be non-competitive (i.e., have no road segments in common) since traffic jams would be engendered if two separate columns had to share the same road.

This project is a joint effort by Louisiana State University (LSU) and the U. S. Army Topographic Engineering Center (TEC). The goal of this project is to develop a two-level hierarchical automated military route planning system by combining software developed at LSU with software developed at TEC. This new system will be called the Predictive Intelligence Military Tactical Analysis System (PIMTAS) and will be applicable to military terrain vehicles (tanks, armored personnel carriers, autonomous land vehicles, etc.). This system will be capable of rapid responses to unpredictable changes in the battlefield environment and will simultaneously handle multiple combat units. The other route planners currently in use are not hierarchical. Thus PIMTAS will be the first hierarchical route planner and as such will be applicable to large terrain maps that cannot be successfully processed by the other current planners.

# 2. Summary of Important Results

- 1) A new thinning function has been developed which quickly thins large, complex images.
- 2) A new, very fast grid level route planner has been developed by combining the LSU and TEC grid level planners. This speed is crucial in combat situations where a few seconds can make the difference between the survival or destruction of the military vehicle.
- 3) The thinning function and grid level route planner described above have been successfully combined with the TEC graph level planner to produce a terrain vehicle version of PIMTAS. In this two-level hierarchical system, the thinning function and a node-merging procedure are used to convert a detailed map of grid points to a graph with a manageable number of nodes. The grid level planner then uses the A\* algorithm to generate an optimum (minimum cost) path between each pair of adjacent graph nodes. The path costs so generated are in turn used as

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13. ABSTRACT (Maximum 200 words)  In this project, which is a joint effort by Louisiana State University (LSU) and the U. S. Army Topographic Engineering Center (TEC), we have developed a two-level hierarchical automated military route planning system by combining software developed at LSU with software developed at TEC. This new system is called the Predictive Intelligence Military Tactical Analysis System (PIMTAS) and is applicable to military terrain vehicles (tanks, armored personnel carriers, autonomous land vehicles, etc.). This software system contains a very fast grid level route planner which was developed by combining the LSU and TEC grid level planners. PIMTAS employs two cost factors, traversal time and enemy threats, to determine the overall cost of the path. By selecting a particular set of weights, the military planner can put any desired degree of emphasis on each of these cost factors. PIMTAS has the capability to handle dynamic (changing) threats. If new threats appear or known threats disappear as the terrain vehicles move along their paths, the military planner can quickly update the battlefield map by using the mouse to add or remove threats. PIMTAS will then rapidly generate a new set of optimum paths, taking into account all of the threats that have been added or removed.				
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input to the graph level planner which employs the A\* algorithm to determine several optimum non-competing routes between any two specified nodes on the graph. Hence this new system provides the capability to efficiently plan a route over a large area while avoiding the combinatorial explosion that would occur if a grid level planner alone were used for such an area. Thus PIMTAS will enable fast and efficient military route planning over the large areas that are typical of modern battle zones, while at the same time retaining the accuracy and detail needed for combat effectiveness and vehicle survivability.

- 4) The capability to select the starting and ending points with the mouse has been added to PIMTAS. This enables the user to choose any points on the map, rather than only graph nodes, as the starting and ending points.
- 5) A new cost factor, enemy threats, has been added to PIMTAS. This threat cost factor is combined with the traversal time cost factor to determine the overall cost of the path. By selecting a particular set of weights, the military planner can put any desired degree of emphasis on each of these cost factors. For example, a large weight for time and a small weight for threats would result in a direct path that may go close to enemy threats, whereas a large weight for threats and a small weight for time would produce a path that stays as far away from threats as possible and consequently may be much longer.
- 6) An efficient threat heuristic has been developed and added to the A\* algorithm in the PIMTAS grid level route planner. This new threat heuristic reduces the running time of the grid level planner. This type of heuristic can also be applied to other cost factors such as visibility.
- 7) The capability to handle dynamic (changing) threats has been added to PIMTAS. If new threats appear or known threats disappear as the terrain vehicles move along their paths, the military planner can quickly update the battlefield map by using the mouse to add or remove threats. PIMTAS will then rapidly generate a new set of optimum paths, taking into account all of the threats that have been added or removed.

### 3. Publications

- 1) S. S. Iyengar, W. Deng, and Nathan E. Brener, A Fast Parallel Thinning Algorithm, Proceedings of the International Workshop on Parallel Processing, Bangalore, India, pp. 100-105, December 1994.
- 2) J. R. Benton, S. S. Iyengar, W. Deng, N. E. Brener, and V. S. Subrahmanian, Tactical Route Planning: New Algorithms for Decomposing the Map, Proceedings of the IEEE International Conference on Tools for Artificial Intelligence, Herndon, VA, pp. 268-277, November 1995.
- 3) J. R. Benton, S. S. Iyengar, W. Deng, N. E. Brener, and V. S. Subrahmanian, Tactical Route Planning: New Algorithms for Decomposing the Map, International Journal on Artificial Intelligence Tools **5**, pp. 199-218, 1996.
- 4) Y. Xia, S. S. Iyengar, and N. E. Brener, An Event Driven Integration Reasoning Scheme for Handling Dynamic Threats in an Unstructured Environment, Artificial Intelligence **95**, pp. 169-186, 1997.

#### **4. Scientific Personnel**

- 1) S. Sitharama Iyengar, Principal Investigator
- 2) Nathan E. Brener, Principal Investigator
- 3) John R. Benton, Principal Investigator
- 4) Weian Deng, Graduate Student, earned Ph.D. in 1994
- 5) Yan Xia, Graduate Student, earned M.S. in 1996

#### **5. Inventions**

None